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Geologic Mapping of Bedrock Units

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GEOLOGIC MAPPING OF BEDROCK UNITS

1.0 PURPOSE

This procedure establishes requirements for the collection, plotting, recording, and interpretation of geologic data to produce a geologic map and associated cross-sections of bedrock (non-soil) units. Because many bedrock exposures in the Los Alamos region occur along tall, vertical cliffs, this procedure also establishes requirements for producing geologic maps on photo mosaics of canyon walls and for recording geologic data on measured stratigraphic sections. Finally, this procedure establishes requirements for collection of rock samples.

2.0 SCOPE

2.1 Applicability

Field geology consists of the methods used to examine and interpret structures and materials at the outcrop and field studies are the primary means of obtaining first-hand geologic knowledge. This procedure applies to all Los Alamos National Laboratory personnel and their subcontractors who will perform geologic mapping of bedrock units for regional or site-specific projects of the Environmental Restoration Program (ERP) being conducted on behalf of Los Alamos National Laboratory.

2.2 Training

Successful completion of college-level courses in stratigraphy, structural geology, field techniques, and geologic mapping or demonstrated experience in geologic mapping through publication are required to use this procedure for ERP projects. Researchers or technicians using this procedure must document that they have read and understood it, as well as the procedures in Section 1.0, General Instructions.

3.0 DEFINITIONS

A. Field geology: The investigation of rocks, rock units, and rock structures in their natural environment and in their natural relations to one another.

B. Bedrock: The solid rock that occurs everywhere beneath a mantle of soil.

4.0 BACKGROUND AND/OR CAUTIONS

This procedure is designed for the Environmental Restoration Program but is based on principles and methods of field geology that are discussed in textbooks on the subject (Lahee, 1941; Compton, 1962). This procedure is an adaptation of U.S. Geol. Survey Technical Procedure GP-01, R1 ("Geologic Mapping") dated 11 August 1988. Because most of Los Alamos National Laboratory and waste sites therein are located on the

most of Los Alamos National Laboratory and waste sites therein are located on the Bandelier Tuff, no researcher or technician can perform competent geologic mapping of bedrock units in this area without referring to works on pyroclastic rocks and ash-flow tuffs (ignimbrites) (e.g., Smith, 1960; Ross and Smith, 1961; Smith and Bailey, 1966; Fisher and Schmincke, 1984). Additionally, the geology and stratigraphic nomenclature of the Los Alamos region have been previously defined and usage refined (Griggs, 1964; Bailey et al., 1969; Smith et al., 1970; Gardner, et al., 1986) thus, all geologic mapping projects for the ERP must adhere to accepted terminology, nomenclature, and usage.

The object of geologic mapping includes identification of geologic features (rock units, faults, geomorphology), definition of their distribution, contact relations, and internal variations, and determination of the age and history of the features. This information provides an understanding of the tectonic and geologic processes that could affect sites and investigations of the ERP at Los Alamos National Laboratory. The information is also required to generate models of tectonism, mass wasting, and geohydrology in the Los Alamos region.

5.0 EQUIPMENT

Equipment required to adequately satisfy this procedure may include, but is not necessarily limited to the following:

- Topographic base maps
- Brunton compass (or equivalent)
- Landscape photographs
- Aerial photographs
- Pocket stereoscope
- Rock hammer
- Hand lens
- Field forms, or ER Field Notebooks
- Altimeter
- Binoculars
- Camera
- Sample bags
- Marking pens, pencils, small drafting implements.
- Daily Activity Log
- Chain-of-Custody/Request for Analysis forms
- Sample Collection Logs
- Variance Logs
- Custody Seals
- Unique Sample Stickers
- Sample Labels

6.0 PROCEDURE

6.1 Objective

The object of this procedure is to produce geologic maps, cross sections, and stratigraphic sections of landforms, surficial deposits (excluding soils), and all bedrock features including rocks, faults, fractures, and folds that may occur within any site or regional area of interest or investigation to the ERP. Because of the unique terrain of this region, geologic maps will be constructed on photo mosaics of cliff walls as well as on standard topographic base maps.

6.2 Methods

Geologic maps are to be constructed through annotation of observations and interpretations pertaining to the geology of the area to be mapped (field area) at their appropriate locations on a previously prepared topographic base map or on photo mosaics.

Observations pertain to geologic features or relations that were observed at a specific place within the field area. Both the nature of the observation and the specific place at which the observation was made are to be recorded at the location on the map or photo representing the actual location. For convenience, the details of the observation may be recorded in ER Field Notebooks or Field Activity Daily Log (see SOP-01.04). If so, the specific place, referred to as a field station, shall be numbered, the number recorded at the location on the map or photo representing the actual location, and the same number with the corresponding observation entered on the Daily Log or the ER Field Notebook. Interpretations shall be similarly recorded.

Interpretations are to be distinguished from observations through use of distinctive symbols on the map, and through clear written distinction in the Daily Log or ER Field Notebook.

Observations and interpretations may be made through visitation and examination (field mapping) of the actual geologic feature. Field mapping may be supplemented or aided through examination and interpretation of aerial photographs of the actual geologic features. In field mapping, observations, interpretations, and/or field stations are to be plotted on a version of the base map (field sheet) or photo carried to the field area, and subsequently replotted on a version of the base map or photo retained at the base camp, field office, or home office. If aerial photographs are employed, observations, interpretations, and field stations may be plotted directly on the aerial photographs and subsequently transferred to a field sheet, to a base map, or to a photo mosaic.

The geologic map shall be drawn on a version of the base map and photo mosaic, and provided with an accompanying explanation. The geologic map and

explanation shall present a synthesis of the geologic information contained in the Daily Log or ER Field Notebook notes, field sheets, other base maps, photos, and such auxiliary information from aerial photographs, sample collections, previously published maps, and other relevant sources of data as may be available. In addition, the geologic map shall present an interpretation of the likely distribution, character and age relationships of the particular geologic features of interest (e.g., rock stratigraphic units, geologic structures, surficial deposits, geomorphic features) consistent with available observational data. Finally, the geologic map, explanation, and supporting documentation and illustrative material (e.g., text and cross-sections), if used, shall distinguish through appropriate symbols or other means that which was observed from that which was interpreted.

6.2.1 Map Scale

This procedure is applicable to geologic mapping of bedrock features at all scales. Specific scales of base maps and photo mosaics are chosen at the discretion of the Principal Investigator (PI) of each site or regional investigation.

6.2.2 Base Maps

Base maps include those prepared by FIMAD or the engineering groups of Los Alamos National Laboratory (a variety of scales <1:24,000) or advance and edition copies of U.S. Geological Survey topographic quadrangle maps at 1:24,000 to 1:100,000 scales. Base maps may be made of paper or transparent plastic such as mylar. Base maps may be cut into pieces or folded for convenient transportability. Plastic overlays may be used to record field station numbers or other data. Photos used for photo mosaics of cliff walls may be of any convenient scale to adequately portray necessary geologic features. Two versions of base maps and photos used for mosaics may be employed. These are field copies for actual field work and compilation copies used in the office for integration of all field data.

6.2.3 Rock Samples of Stratigraphic Units

Hand samples should be collected from the outcrop or from artificial exposures (man-made cuts and pits) and retained in sufficient number to represent the dominant lithologies and significant variants of all mapped rock stratigraphic units. Samples of rock stratigraphic units should normally be obtained by breaking the prospective sample from the outcrop, using a hammer or hammer and chisel. If the sample is taken from material previously separated from the outcrop (e.g., float or talus) that fact should be recorded in the Daily Log or ER Field Notebooks. Samples may be bagged in plastic, cloth, or paper bags if necessary to prevent loss, damage or contamination of the sample during handling, transit, and storage.

Samples of friable materials (soils, uncemented aggregates) should be collected directly from the bed, stratum, or deposit they are to represent, using implements appropriate to the purpose (e.g., shovels, trowels), taking care to prevent contamination of the sample through accidental inclusion of foreign material, and bagged in plastic, cloth, or paper bags.

Processing of these samples is limited to preparation of thin-sections, polished sections, grain mounts, and measurement of physical properties (e.g., specific gravity) or other nondestructive procedures. However, portions of a sample may be removed for destructive tests (e.g., chemical analysis) provided sufficient material remains, in the judgement of the PI, to fulfill the primary purpose of the sample, as described above.
Specialized sampling for other purposes (e.g., dating), which may be necessary or desirable, is outside the scope of this procedure.

6.2.4 Photographs

Aerial photographs (vertical or oblique, color or black and white) may be used as described above to observe, interpret, and plot geologic features and field stations. If annotated, the photographs become part of the formal data base. If not annotated, the photographs are regarded as part of the informal data base, requiring no special documentation or custodial care.

Photographs of specific geologic features may be taken using hand-held cameras as part of field data collection. The field location, frame number, azimuth (approximate), and object of the photograph are to be recorded in the Daily Log or ER Field Notebooks. As soon as practicable thereafter, a print or duplicate transparency of the photograph should be correlated with the information in the Daily Log or ER Field Notebooks, the print or transparency labeled in such a way that this information can be recovered, and filed as part of the formal data base. Other prints, positives, and negatives of the same photograph may be retained by the PI as part of an informal data base, to be used for other purposes, and requiring no special documentation or custodial care.

6.2.5 Attitude of Planar and Linear Features

The attitude of planar and linear features may be measured using hand-held devices (e.g., Brunton compasses) at the discretion of the PI. The measurement may be entered directly on field sheets, aerial photographs, or on Daily Logs or ER Field Notebooks. Magnetic declination will be compensated for by adjustment of the compass to the local declination, or through adjustment of the measurement.

6.2.6 Field Notebooks

Field notebooks may be used if preferred over Daily Log Sheets. The ER Field Notebooks will have perforated sheets that may be removed and attached to field forms, photographs, or other pertinent record information in a record package. The sheets in the ER Field Notebooks must have printed sequential numbers, and the header information on each set of sheets must be complete. In addition the notebooks sheets must contain, as appropriate:

- Title of mapping activity;
- Description of the objective of the mapping activity;
- Identification and scale of field sheets and base map(s) used in the mapping; and
- Equipment used.

Other information may be included, such as, weather and field conditions, sample information, data collected, or diviations, if this information is not included elsewhere.

At the conclusion of the mapping, the final results and a summary of the outcome of the mapping shall be provided. This summary shall include a discussion of whether the mapping objectives, as outlined in the initial entries, were achieved. The summary shall also include a reference to a completed and published report or map; or the summary will be provided in the field notebook. The field notes shall be reviewed and signed by a Technical reviewer.

6.3 Assumptions Affecting the Procedure

A basic assumption is that the individuals applying this procedure are competent, well-trained geologic mappers.

6.4 Data Information

Data collected using this procedure is presented as a geologic map, with accompanying explanation and optional cross-sections, and character of rock- and/or soil-stratigraphic units, geomorphic features, faults, folds, and fractures, their age relationships, and their geologic history.

6.4.1 Quantitative/Qualitative Criteria

An acceptable general purpose geologic map should meet the following criteria:

1. The map should be on a base that meets National Map Accuracy Standards. A topographic base is essential except on small scale maps or in areas of such low relief that the absence of contours does not hinder geologic interpretation. Bedrock geology portrayed on photo mosaics of cliff faces should show obvious reference features or structures.

2. The completed map should be clearly readable and usable at publication scale. All symbols on the map should be fully explained in the marginal material, if not in common usage. The sources of geologic data should be indicated for all parts of the map. Contacts inferred from geophysical, photogeologic, or remote sensing data should be identified and explained.

3. All geologically significant units mappable at the scale selected should be shown, and geologic features should be depicted uniformly throughout the area of the map.

4. Mines, prospects, quarries, wells, trenches, test pits, and drill holes should be shown to the extent possible at the map scale.

5. Geologic interpretations should be internally consistent and plausible. Relations of normal contacts of geologic units to topography should be consistent with rock attitudes, stratigraphy, and structure shown on the map and in cross sections.

6. Structure should be adequately portrayed. Attitudes of significant structural features should be indicated wherever practical. Structure sections should be included if needed for clarity, and these should be consistent with relations depicted on the map.

7. Surficial units should be distinguished and, where possible, subdivided on the basis of age, origin, morphology and/or lithology. If the map meets all criteria but this, it should be termed as bedrock geologic map. If it meets this criterion, but does not portray the bedrock units, it should be termed a surficial geologic map. In some cases several maps may be required to provide adequate general purpose coverage of an area.

8. Faults that display mappable offset of stratigraphic or lithologic units or which display evidence of recent movement, or are of some other special significance, should be mapped and classified as to type (normal, reverse, thrust, strike-slip, etc.); and dip and direction of relative movement should be shown wherever possible.

9. The explanation should be concise and reasonably definitive, and should express the distinctive characteristics and principal variations in the map units. Map units (including surficial units) should be described in terms of lithologic character, physical properties, thickness (where possible), economic significance, geologic and/or absolute age and contact relations. Definition of map units and stratigraphic nomenclature should be consistent with current USGS standards.

6.5 Calibration Requirements

Calibration is not required as a part of this technical procedure.

6.6 Sample Identification

As part of the data records and documentation, all samples will be identified as follows: All samples will be labeled with a unique identifier, using indelible ink whenever possible. Samples with surfaces too rough to mark, or too porous to mark, will be placed in bags and the bags will be marked with the unique sample identifier. Sample identifiers will be recorded on field sheets, base maps, or photos as deemed appropriate by the PI. PIs shall assure that the original sample identifier is traceable to all documentation associated with the samples, and is maintained when the samples are handled by different organizations. All sampling efforts must be coordinated with the Sample Coordination Facility.

6.7 Control and Storage

Samples collected during this work shall be identified and controlled in accordance with the procedure for Sample Control and Field Documentation. (LANL-ER-SOP-01.04).

6.8 Special Treatment

Samples shall be prepared for examination or analyses according to the purpose for which they were collected. Samples are to be routinely prepared for petrographic or geochemical analyses.

7.0 REFERENCES

Lahee, F. H. 1941. Field Geology: McGraw-Hill, New York.

Compton, R. R. 1962. Manual of Field Geology: Wiley & Sons, New York.

Fisher, R. V. and H. U. Schmincke. 1984. Pyroclastic Rocks: Springer-Verlag, New York.

Ross, C. S. and R. L. Smith. 1961. Ash-flow Tuffs: Their Origin, Geologic Relations, and Identification: U.S. Geol. Survey, Prof. Paper 366, 81 p.

Smith, R. L. 1960. Zones and Zonal Variations in Welded Ash Flows: U.S. Geol. Survey, Prof. Paper 354-F, p. 149-159.

Smith, R. L. and R. A. Bailey. 1966. The Bandelier Tuff: A Study of Ash-flow Eruption Cycles from Zoned Magma Chambers: Bul. Volcano. v. 29, p. 83-104.

Griggs, R. L. 1964. Geology and Groundwater Resources of the Los Alamos Area, New Mexico: U. S. Geol. Survey, Water Supply Paper 1753.

Bailey, R. A., R. L. Smith, and C. S. Ross. 1969. Stratigraphic Nomenclature of Volcanic Rocks in the Jemez Mountains, New Mexico: U. S. Geol. Survey, Bull. 1274-P.

Smith, R. L., R. A. Bailey, and C. S. Ross. 1970. Geologic Map of the Jemez Mountains, New Mexico: U.S. Geol. Survey, Miscell. Geol. Invest. Map I-57.

Gardner, J. N., F. Goff, S. Garcia, and R. C. Hagan. 1986. Stratigraphic Relations and Lithologic Variations in the Jemez Volcanic Field, New Mexico: Jour. Geophys. Res., v. 91, p. 1763-1778.

LANL-ER-SOP-Section 1.0, General Instructions.

8.0 RECORDS

All information collected and recorded under this procedure and that is to be used in support of the Los Alamos ERP must become a part of the official record. Information needed to process each item as a record includes: title or description, subject, originator, date of the document, and whether it is an original, a revision or an addendum.

Specific items from this procedure that will constitute a record are ER Field Notebooks, in their entirely or sheets thereof, field sheets, base maps, annotated aerial photographs, samples, photographs of specific features using hand-held cameras, and logbooks.

8.1 Field

All organized documentation will be prepared as appropriate by the PI or a contributing investigator to record data from this procedure and shall include any information considered pertinent. Each page of documentation will be numbered consecutively and chronologically. Information superseded as a result of any revisions will be lined out, initialed, and dated. All documents will be signed or initialed and dated by the investigator on a daily basis when entries are made.

8.2 Review

All data collected and the applicability of methods used in this procedure will be reviewed and cosigned by a peer or supervisor of the investigator who is knowledgeable in the objectives of this procedure. This indicates that the data are acknowledged by both the investigator and the reviewer to be acceptable and meaningful data that meet appropriate quantitative and qualitative acceptance criteria. Unacceptable data shall be identified in a manner appropriate to the form of the data.

9.0 ATTACHMENTS

N/A